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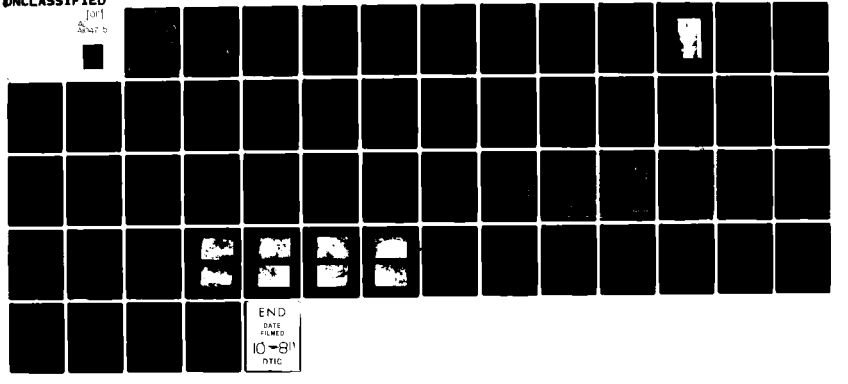

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CEDAR GROVE LAKE DAM

WARREN COUNTY, MISSOURI

MO 11075

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

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1. REPORT NUMBER	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle) Phase I Dam Inspection Report National Dam Safety Program Cedar Grove Lake Dam (MO 11075) Warren County, Missouri	5. TYPE OF REPORT & PERIOD COVERED Final Report
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Horner & Shifrin, Inc.	8. CONTRACT OR GRANT NUMBER(s) DACW43-80-C-0063
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Army Engineer District, St. Louis Dam Inventory and Inspection Section, LMSED-PD 210 Tucker Blvd., North, St. Louis, Mo. 63101	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS U.S. Army Engineer District, St. Louis Dam Inventory and Inspection Section, LMSED-PD 210 Tucker Blvd., North, St. Louis, Mo. 63101	12. REPORT DATE September 1980
	13. NUMBER OF PAGES Approximately 55
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	15. SECURITY CLASS. (of this report) UNCLASSIFIED
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

National Dam Safety Program. Cedar Grove Lake Dam (MO 11075), Missouri - Kansas City Basin, Warren County, [redacted] Missouri. Phase I Inspection Report.

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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

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18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Dam Safety, Lake, Dam Inspection, Private Dams

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.

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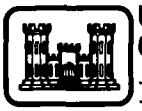
CEDAR GROVE LAKE DAM

WARREN COUNTY, MISSOURI

MO 11075

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM



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St. Louis District

PREPARED BY: U.S. ARMY ENGINEER DISTRICT, ST. LOUIS

FOR: STATE OF MISSOURI

SEPTEMBER 1980

DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 TUCKER BOULEVARD, NORTH
ST. LOUIS, MISSOURI 63101

REPLY TO ATTENTION OF

LMSED-P

SUBJECT: Cedar Grove Lake Dam, MO 11075, Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Cedar Grove Lake Dam (MO 11075):

It was prepared under the National Program of Inspection of Non-Federal Dams.

This dam has been classified as unsafe, non-emergency by the St. Louis District as a result of the application of the following criteria:

1) Spillway will not pass 50 percent of the Probable Maximum Flood without overtopping the dam.

2) Overtopping of the dam could result in failure of the dam.

3) Dam failure significantly increases the hazard to loss of life downstream.

SIGNED

SUBMITTED BY: _____
Chief, Engineering Division

14 OCT 1980
Date

SIGNED

APPROVED BY: _____
Colonel, CE, District Engineer

14 OCT 1980
Date

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CEDAR GROVE LAKE DAM

MISSOURI INVENTORY NO. 11075

WARREN COUNTY, MISSOURI

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

PREPARED BY:

HORNER & SHIFRIN, INC.
5200 OAKLAND AVENUE
ST. LOUIS, MISSOURI 63110

FOR:

U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS

SEPTEMBER 1980

HS-8011

PHASE I REPORT

NATIONAL DAM SAFETY PROGRAM

Name of Dam:	Cedar Grove Lake Dam
State Located:	Missouri
County Located:	Warren
Stream:	Tributary of Lost Creek
Date of Inspection:	26 June 1980

The Cedar Grove Lake Dam was visually inspected by engineering personnel of Horner & Shifrin, Inc., Consulting Engineers, St. Louis, Missouri. The purpose of this inspection was to assess the general condition of the dam with respect to safety and, based upon this inspection and available data, determine if the dam poses a hazard to human life or property.

The following summarizes the findings of the visual inspection and the results of certain hydrologic/hydraulic investigations performed under the direction of the inspection team. Based on the visual inspection and the results of these hydrologic/hydraulic investigations, the present general condition of the dam is considered to be unsatisfactory.

The following deficiencies were noticed during the inspection and are considered to have an adverse effect on the overall safety and future operation of the dam:

1. An area of seepage with cattails, soft ground and flowing water, exists in the vicinity of the downstream channel and the toe of the dam. Uncontrolled seepage can develop into a piping condition (progressive internal erosion) that could result in failure of the dam.

2. A dense growth of brush and small-to-medium size trees exists on the upstream and downstream faces of the dam. Tree roots can provide passageways for lake seepage which could lead to a piping condition that could result in failure of the dam. Brush may conceal animal burrows which could also provide passageways for lake seepage.

3. The dam, according to survey data obtained during the inspection, appears to have settled, perhaps as much as 1.0 foot, in the vicinity of the original stream crossing. As a result of this suspected settlement, the area at the right abutment intended to be an emergency spillway is negated, and the only effective outlet for lake surcharge is the 6-inch diameter pipe spillway.

4. An extensive development of cattails exists at the lake shoreline in the vicinity of the upstream end of the 6-inch pipe spillway. In addition to impeding flow to the pipe, the cattails can hinder maintenance of the pipe during periods when blockage by floating objects and/or debris occurs.

5. The upstream face of the dam has only a vegetative type of cover to prevent erosion by wave action or by fluctuations of the lake level. Vegetation is not considered adequate protection to prevent erosion by wave action or fluctuations of the lake level.

According to the criteria set forth in the recommended guidelines, the magnitude of the spillway design flood for the Cedar Grove Lake Dam, which is classified as small in size and of high hazard potential, is specified to be a minimum of one-half the Probable Maximum Flood (PMF). Considering the fact that the downstream floodplain within the estimated flood damage zone is quite narrow and that most of the dwellings within the floodplain lie near the channel at an elevation not too much higher than the stream bank, it is recommended that the spillway for this dam be designed for the PMF. The Probable Maximum Flood (PMF) is the flood that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The PMF is ordinarily accepted as the

inflow design flood for dams where failure of the structure would seriously increase the danger to human life.

Results of a hydrologic/hydraulic analysis indicated that the 6-inch pipe spillway is inadequate to pass lake outflow resulting from a storm of PMF magnitude. The spillway is capable, however, of passing lake outflow resulting from the one percent chance (100-year frequency) flood and the outflow corresponding to about 20 percent of the PMF without overtopping the dam. According to the St. Louis District, Corps of Engineers, the length of the downstream damage zone, should failure of the dam occur, is estimated to be three miles. Accordingly, within the possible damage zone are seven dwellings and a county road.

A review of available data did not disclose that seepage or stability analyses of this dam were performed. This is considered a deficiency and should be rectified.

It is recommended that the Owner take the necessary action without undue delay to correct or control the deficiencies and safety defects reported herein. The provision of additional spillway capacity should be pursued on a high priority basis.

Ralph E. Sauthoff

Ralph E. Sauthoff
P. E. Missouri E-19090

Albert B. Becker, Jr.

Albert B. Becker, Jr.
P. E. Missouri E-9168

OVERVIEW CEDAR GROVE LAKE DAM

PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

CEDAR GROVE LAKE DAM - MO 11075

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PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

CEDAR GROVE LAKE DAM - MO 11075

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

a. Authority. The National Dam Inspection Act, Public Law 92-367, dated 8 August 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of safety inspection of dams throughout the United States. Pursuant to the above, the St. Louis District, Corps of Engineers, directed that a safety inspection of the Cedar Grove Lake Dam be made.

b. Purpose of Inspection. The purpose of this visual inspection was to make an assessment of the general condition of the dam with respect to safety and, based upon available data and this inspection, determine if the dam poses a hazard to human life or property.

c. Evaluation Criteria. This evaluation was performed in accordance with the "Phase I" investigation procedures as prescribed in "Recommended Guidelines for Safety Inspection of Dams," Appendix D to "Report to the Chief of Engineers on the National Program of Inspection of Non-Federal Dams," dated May 1975

1.2 DESCRIPTION OF PROJECT

a. Description of Dam and Appurtenances. The Cedar Grove Lake Dam is an earthfill type embankment rising approximately 32 feet above the original streambed at the downstream toe of the barrier. The embankment has an irregular upstream slope (above the waterline) that varies from approximately 1v on 3.0h to about 1v on 1.4h, a crest width on the order of 14 feet, and a downstream slope of about 1v on 2.0h, although in some locations and particularly near the center of the dam, the upper 6 feet of the downstream

slope tends to be steeper than 1v on 2.0h. The length of the dam is approximately 300 feet. A plan and profile of the dam are shown on Plate 3 and a cross-section of the dam is shown on Plate 4. At normal pool level the reservoir impounded by the dam occupies approximately three acres. It was reported that the lake has a drawdown pipe; however, the pipe was not located at the time of the inspection.

The dam spillway, a 6-inch diameter asbestos-cement pipe, passes through the hillside at the right abutment. A low area in the dam crest located directly above the pipe outlet appears to have been intended to serve as an emergency spillway. However, its effectiveness as an outlet for lake surcharge is negated by the fact that the top of the dam at the location of the original stream crossing is approximately 0.3 foot lower than the low point of the intended emergency spillway. The outlet channel for the pipe spillway is an irregular V-section that joins the natural drainage course of the adjoining valley at a point approximately 60 feet downstream of the dam. This drainage course joins the stream on which the dam is constructed at a location approximately 140 feet downstream of the dam. A profile of the spillway pipe is shown on Plate 4.

b. Location. The dam is situated on an unnamed tributary of Lost Creek, within the Cedar Hills Subdivision development; the entrance to which is located on the west side of State Highway U about three miles southwest of Warrenton, Missouri, as shown on the Regional Vicinity Map, Plate 1. The dam is located in the southeast quadrant of Section 36, Township 47 North, Range 3 West, within Warren County.

c. Size Classification. The size classification based on the height of the dam and storage capacity, is categorized as small. (Per Table 1, Recommended Guidelines for Safety Inspection of Dams.)

d. Hazard Classification. The Cedar Grove Lake Dam. according to the St. Louis District, Corps of Engineers, has a high hazard potential, meaning that if the dam should fail, there may be loss of life, serious damage to homes, or extensive damage to agricultural, industrial and commercial facilities, important public utilities, main highways, or railroads. The estimated flood

damage zone, should failure of the dam occur, as determined by the St. Louis District, extends three miles downstream of the dam. Within the possible damage zone are seven dwellings and a county road. Those features lying within the downstream damage zone reported by the Corps of Engineers, St. Louis District, were verified by the inspection team.

e. Ownership. The lake and dam are on common ground that is owned jointly by individuals that reside within the Cedar Grove Subdivision. Management of the common ground is by subdivision trustees who represent the Cedar Grove Subdivision Property Owners Association. The head trustee is Mr. Pearl L. Keene. Mr. Keene's address is 35 Meadow Lane, Rural Route 3, Warrenton, Missouri 63383.

f. Purpose of Dam. The dam impounds water for recreational purposes.

g. Design and Construction History. According to Mr. Edward Juncker, the developer of the Cedar Grove Subdivision, the dam was constructed in 1965 by Russell Bolinger, a local earth moving contractor and builder of earthen dams. Mr. Bolinger is deceased and no records of the design of the dam are known to exist. Mr. Juncker presently operates the Farm & Home Realty Company, Warrenton, Missouri.

h. Normal Operational Procedure. The lake level is unregulated. Lake outflow is governed by the capacity of a 6-inch diameter pipe outlet.

1.3 PERTINENT DATA

a. Drainage Area. The drainage area tributary to the lake consists mostly of land that has been subdivided into lots that vary in size from about 1.3 acres to approximately 3.4 acres. Mobile homes occupy most of the lots. Judging by the extensive tree cover in the area it would appear that very little grading was done by the developer to improve the land. State Highway U, an asphalt surfaced road, traverses the east side of the drainage area. The watershed above the dam amounts to approximately 28 acres. The watershed area is outlined on Plate 2.

b. Discharge at Damsite.

(1) Estimated known maximum flood at damsite ... 1 cfs* (W.S. Elev. 821.

(2) Spillway capacity ... 1 cfs (W.S. = 822.0)

c. Elevation (Ft. above MSL). The following elevations were determined by survey and are based on topographic data shown on the 1973 Warrenton, Missouri, Quadrangle Map, 7.5 Minute Series.

(1) Observed pool ... 818.7

(2) Normal pool ... 819.0

(3) Spillway crest ... 819.0

(4) Maximum experienced pool ... 821.0*

(5) Top of dam ... 822.0 (min.)

(6) Streambed at centerline of dam ... 795± (est.)

(7) Maximum tailwater ... Unknown

(8) Observed tailwater ... None

d. Reservoir.

(1) Length at normal pool (Elev. 819.0) ... 600 ft.

(2) Length at maximum pool (Elev. 822.0) ... 640 ft.

e. Storage.

(1) Normal pool ... 20 ac. ft.

(2) Top of dam (incremental) ... 14 ac. ft.

f. Reservoir Surface.

(1) Normal pool ... 3 acres

(2) Top of dam (incremental) ... 3 acres

* Based on an estimate of lake level as observed by Mr. P. L. Keene.

g. Dam. The height of the dam is defined to be the overall vertical distance from the lowest point of foundation surface at the downstream toe of the barrier to the top of the dam.

(1) Type ... Earthfill, homogeneous*
(2) Length ... 300 ft.
(3) Height ... 32 ft.
(4) Top width ... 14 ft.
(5) Side slopes
    a. Upstream ... 1v on 3.0h to 1v on 1.4h (above waterline)
    b. Downstream ... 1v on 2.0h (irregular)
(6) Cutoff ... Clay core*
(7) Slope protection
    a. Upstream ... Grass
    b. Downstream ... Grass

h. Principal Spillway.

(1) Type ... Uncontrolled, 6-inch diameter asbestos-cement pipe
(2) Location ... Right abutment
(3) Invert elevation
    a. Upstream ... 819.00
    b. Downstream ... 818.45
(4) Approach channel ... Lake
(5) Exit channel ... Earthen V-section

i. Emergency Spillway ... None

j. Lake Drawdown Facility. According to Mr. Ed. Juncker, the subdivision developer, a lake drawdown pipe was believed to have been installed at the time the dam was constructed; however, no pipe was found by the inspection team and no additional information regarding the pipe or its location was available.

* Per Mr. Ed. Juncker, subdivision developer.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

No data relating to the design of the dam are known to exist.

2.2 CONSTRUCTION

As previously stated, the dam was constructed in 1965 by Russell Bolinger (deceased), a local contractor and dam builder. No records of the construction work are known to exist. According to Mr. Ed Juncker, the developer of the Cedar Grove Subdivision, a core trench approximately 6-to-10 feet in depth was excavated along the alignment of the dam. Mr. Juncker reported that the trench was not carried to bedrock but to a depth where good clay was encountered. Mr. Juncker also stated that compaction of embankment material was obtained by running the earth moving equipment over the fill but that density tests to check compaction were not performed.

2.3 OPERATION

The lake level is uncontrolled and governed by the crest elevation of the pipe spillway located at the right abutment of the dam. According to Mr. Pearl Keene, the head of the subdivision trustees, to the best of his knowledge, the dam has never been overtopped. Possible indication was found that the dam has been overtopped; as noted in Section 3.1c, the upper 10 feet, or so, of the downstream face of the dam near the center was noticeably steeper than the lower section of the slope, and some evidence of erosion, or possibly sloughing of the slope, was observed during the inspection. Mr. Keene reported that the maximum flood experienced by the dam within the last three years occurred in April of 1979 when the lake surface reached a level approximately two feet higher than the normal pool level. However, Mr. Keene also reported that the spillway pipe was clogged at the time, and when the pipe was cleared, the lake returned to normal level.

2.4 EVALUATION

a. Availability. Engineering data for assessing the design of the dam and spillway were unavailable.

b. Adequacy. No data available. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General. A visual inspection of the Cedar Grove Lake Dam was made by Horner & Shifrin engineering personnel, R. E. Sauthoff, Civil Engineer, and A. B. Becker, Jr., Civil and Soils Engineer, on 26 June 1980. An examination of the dam area was also made by an engineering geologist, Jerry D. Higgins, Ph.D., a consultant retained by Horner & Shifrin for the purpose of assessing the site geology. Also examined at the time of the inspection were the areas and features below the dam within the potential flood damage zone. Photographs of the dam taken at the time of the inspection are included on pages A-1 through A-4 of Appendix A. The locations of the photographs taken during the inspection are indicated on Plate 3.

b. Site Geology. The topography of the reservoir area is gently sloping with a maximum of approximately 70 feet of relief between the reservoir and the drainage divide one-quarter mile northeast. The site is located near the southern border of the Dissected Till Plains Section of the Central Lowlands Physiographic Province and the northern edge of the Ozark Plateaus Physiographic Province.

The area is underlain by thick glacial and residual deposits with no bedrock exposures evident at the site. Reportedly, the bedrock consists of gently northward-dipping Mississippian-age sedimentary strata of the Burlington-Keokuk formations. Fragments of Burlington-Keokuk limestones were noted in the residual soils on the dam abutments. No faults were observed or are reported to be present in this area. The Burlington-Keokuk formations are light gray to buff colored, coarsely crystalline, fossiliferous, crinoidal limestones. The limestones are medium-bedded and contain abundant chert in the form of layers and nodules. These formations are well known for solution-weathered features including sinkholes, caves, solution-enlarged joints or bedding planes, and a highly irregular bedrock surface. The presence of these features often causes severe reservoir leakage. No evidence of these karst features was noted in the dam or reservoir area. The thick

soil cover would tend to mask any surface expression of these features and minimize their effects on the performance of the reservoir and dam.

The unconsolidated surficial materials in the vicinity of the reservoir are composed principally of soils derived from glacial till and loess overlying bedrock residuum. Excavation for the dam has cut through the glacial soils exposing the residual soils of the Gasconade series in the valley bottom. This series consists of shallow, somewhat excessively drained soils derived from weathering of limestone. The soils consist of dark grayish-brown, stony (limestone and chert fragments), silty clays near the surface and rapidly grade into dark brown silty clay with depth. According to the Unified Soil Classification System, the soils range in classification from CL to GC, are moderately permeable, and generally thin. Seepage problems are common. Overlying the residuum and covering the valley walls are soils of the Lindley series. These are deep, well-drained soils formed on glacial till. The soil typically ranges from a silty clay at the surface, becoming more clayey with depth. Chert fragments from the reworked residual soils are common. The soils are classified as CL-ML to CL materials, exhibit moderately low permeability, and are generally considered favorable for impoundments and embankments. The surrounding uplands are covered with soils of the Hatton series. These are moderately well-drained clays and silty clays formed from loess and the underlying glacial sediment. These soils are only present well above the reservoir and dam site.

No adverse geologic conditions were observed that would be considered to severely affect the performance of the reservoir or the stability of the embankment.

c. Dam. The visible portions of the upstream and downstream faces of the dam (see Photos 1 and 2) as well as the dam crest (see Photo 3), were inspected and, except as noted herein, appeared to be in sound condition. However, due to the presence of dense brush and trees, some as large as 8 inches in diameter, all areas of the dam could not be thoroughly examined.

Based on survey data obtained during the inspection, it appeared that, in the vicinity of the original stream crossing, the dam had settled

approximately 1.0 foot. As a result of this settlement, the dam crest at the location of the original stream crossing was found to be at a lower elevation than the top of the dam at the right abutment which appeared to have been intended as an emergency spillway. Also, near the center of the dam, the upper 10 feet, or so, of the downstream face was noticeably steeper than the lower section of the slope and some evidence of erosion or possibly sloughing of the slope was noted.

Numerous surface cracks, up to 1/2 inch in width and 5 inches in depth and as long as 4 feet, were observed in the crest of the dam adjacent to a footpath that traversed the dam. The cracks extended primarily in the longitudinal direction of the dam and appeared to be a result of shrinkage of the soil due to drying. Examination of a soil sample obtained from the downstream face of the dam indicated the material to be a yellow, silty lean clay (CL) of low to medium plasticity.

A marshy area (see Photo 7) approximately 50 feet wide and 50 feet long with cattails and soft, wet ground, existed just downstream of the center of the dam. Since the outlet channel for the spillway pipe conducted flow through the area, it could not be determined if the marsh was caused by dam seepage or if it was a result of poor drainage through the area by unconfined spillway releases. In any event, no flowing water was noticed in this area. Seepage flow (see Photo 8) on the order of 1 gpm was observed in the original stream channel just downstream of the dam. Judging by the reddish residue covering the entire invert of the channel, a characteristic of dam seepage, the amount of seepage within the stream channel was probably several times greater at one time than that observed during the inspection.

The upstream and downstream ends of the 6-inch diameter asbestos-cement pipe spillway (see Photos 4 and 5) were examined and found to be in sound condition. A dense growth of cattails was present in the lake in the vicinity of the spillway pipe and a dense growth of high weeds was found on the lake bank in the area of the pipe. A minor amount of embankment erosion was noticed at the outlet end of the pipe which allowed about 15 inches of the end of the pipe to project unsupported from the bank. The outlet channel for the spillway pipe joined the drainage course of the adjacent valley just downstream of the end of the pipe which, in turn, joined the original stream

channel on which the dam is constructed at a point about 50 feet downstream of the dam toe. The channel for the most part was not well defined and in an unkept condition (see Photo 6) through the area just downstream of the dam. Near the junction with the downstream channel, flow was unconfined and, as previously mentioned, a marshy area existed.

A potable water line that serves the residences north of the lake traverses the dam. A valve installed on the line at a depth about 3 feet below the ground surface and protected by a section of plastic pipe was observed at the left abutment of the dam.

d. Appurtenant Structures. No appurtenant structures were observed at this dam site.

e. Downstream Channel. Except for two, low-water type bridges crossing the stream, the channel downstream of the dam, within the limits of the flood damage zone, is unimproved. The tributary on which the dam is constructed joins Lost Creek at a point approximately 0.6 mile downstream of the dam. A county maintained road closely parallels the creek downstream of the dam.

f. Reservoir. The shoreline about the lake is for the most part covered with trees, although, numerous areas of extensive growths of cattails exist, particularly along the north side of the lake. According to Mr. Ed Juncker, the developer of the Cedar Grove Subdivision, the lake is supposed to be 28 feet deep at its deepest point; however, he is of the opinion that there may be as much as 10 feet of sediment within the lake. The actual amount of sediment within the lake could not be determined at the time of the inspection. At the time of the inspection, the lake was just below normal pool level and the water in the reservoir was slightly cloudy.

3.2 EVALUATION

The deficiencies observed during the inspection and noted herein are not considered of significant importance to warrant immediate remedial action. It is recommended that the trees and brush be removed from the embankment, as indicated in paragraph 7.2b(2), as soon as practical and the entire dam be reexamined by an engineer as specified therein.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

The spillway is uncontrolled. The water surface level is governed by precipitation runoff, evaporation, seepage, and the capacity of the uncontrolled pipe spillway.

4.2 MAINTENANCE OF DAM

According to Mr. Pearl Keene, the head of the subdivision trustees, with the exception of clearing the clogged spillway pipe during a period when the dam was endangered by rising water, the dam has received no recent maintenance work. Judging by the extensive growth of trees and brush on the dam proper, the apparent settlement of the dam at the location of the original stream crossing, and the lack of provisions to control seepage, it is evident that maintenance of the dam has been neglected for quite some time.

4.3 MAINTENANCE OF OPERATING FACILITIES

With the possible exception of the valve on the lake drawdown pipe which could not be located at the time of the inspection and may not even exist, no outlet facilities requiring operation exist at this dam, and there is no reservoir regulation plan.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT

The inspection did not reveal the existence of a dam failure warning system.

4.5 EVALUATION

Lack of maintenance is considered detrimental to the safety of the dam. It is recommended that maintenance of the dam be undertaken on a regular basis and that records be kept of all major items of work performed. It is also

recommended that a detailed inspection of the dam be instituted on a regular basis by an engineer experienced in the design and construction of dams and that records be kept of all inspections made and remedial measures taken.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

a. Design Data. Design data were not available.

b. Experience Data. The drainage area and lake surface area were developed from the 1973 USGS Warrenton, Missouri, Quadrangle Map. The proportions and dimensions of the spillway and dam were developed from surveys made during the inspection. Records of rainfall, streamflow, or flood data for the watershed were not available.

Due to the fact that the watershed for this reservoir is small, the lake level was assumed to be at normal pool as a result of antecedent storms prior to occurrence of the PMF and the probabilistic storm.

According to the St. Louis District, Corps of Engineers, the estimated flood damage zone, should failure of the dam occur, extends three miles downstream of the dam.

c. Visual Observations.

(1) The spillway, a 6-inch diameter asbestos-cement pipe, is located at the junction of the dam and the right abutment. The spillway outlet channel joins the original stream channel at a point about 140 feet downstream of the dam.

(2) There is no emergency spillway. Apparent settlement of the dam at the original stream crossing has caused the top of the dam at this location to be lower than the crest of the section presumed to be an emergency outlet.

(3) The original stream channel abuts the toe of the dam.

d. Overtopping Potential. The spillway is inadequate to pass the probable maximum flood, or 1/2 the probable maximum flood, without overtopping the dam. The results of the dam overtopping analyses are as follows:

(Note: The data appearing in the following table has been extracted from the computer output data appearing in Appendix B. Decimal values have been rounded to the nearest one-tenth in order to prevent assumption of unwarranted accuracy.)

Ratio of PMF	Q-Peak Outflow (cfs)	Max. Lake W.S. Elev.	Max. Depth (Ft.) of Flow over Dam (Elev. 822.0)	Duration of Overtopping of Dam (Hours)
0.50	195	823.2	1.2	9.2
1.00	596	823.6	1.6	11.1

Elevation 822.0 was found to be the lowest point in the dam crest. The flow safely passing the spillway, just prior to overtopping amounts to approximately 1 cfs, which is the routed outflow corresponding to about 20 percent of the probable maximum flood inflow. During peak flow of the probable maximum flood, the greatest depth of flow over the dam is projected to be 1.6 feet and overtopping will extend across the entire length of the dam.

e. Evaluation. Examination of the surficial material of the dam indicated it to be a yellow, silty lean clay of low-to-medium plasticity. Experience indicates that this type of material, under certain conditions, such as high velocity flow, can be very erodible. Such a condition exists during the PMF when large lake outflow, accompanied by high flow velocities, occurs. For the PMF condition where the depth of flow over the dam crest, a maximum of 1.6 feet, and the duration of flow over the dam, 11.1 hours, are appreciable, damage by erosion to the crest and downstream face of the dam is expected. The extent of these damages is not predictable within the scope of these investigations; however, there is a possibility that they could result in failure by erosion of the dam.

f. References. Procedures and data for determining the probable maximum flood, the 100-year frequency flood, and the discharge rating curve for flow passing the spillway and dam crest are presented on pages B-1 and B-2 of the Appendix. Listings of the HEC-1 (Dam Safety Version) input data for both the

probable maximum flood and the 100-year frequency flood are shown on pages B-3 through B-5. Computer output data, including unit hydrograph ordinates, tabulation of PMF rainfall, loss and inflow data are shown on pages B-6 through B-9; tabulation of lake surface area, elevation and storage volume is shown on page B-10; and tabulations titled "Summary of Dam Safety Analysis" for the PMF and 1 percent chance (100-year frequency) flood are also shown on page B-10.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations. Visual observations of conditions which adversely affect the structural stability of the dam are discussed in Section 3, paragraph 3.1c.

b. Design and Construction Data. No design or construction data relating to the structural stability of the dam are known to exist. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record.

c. Operating Records. With the possible exception of a valve on the lake drawdown pipe which could not be located at the time of the inspection, no appurtenant structures or facilities requiring operation exist at this dam. According to Mr. P. L. Keene, the head subdivision trustee, no records are kept of the lake level, spillway discharge, dam settlement, or seepage.

d. Post Construction Changes. Mr. Keene reported that, to his knowledge, no post construction changes have been made or have occurred, which would affect the structural stability of the dam. A possible exception is the suspected settlement of the dam, believed to be on the order of 1.0 foot, that has occurred in the vicinity of the original stream crossing.

e. Seismic Stability. The dam is located in an area close to the boundary separating the Zone I and Zone II seismic probability areas. An earthquake of the magnitude that might occur in this area would not be expected to cause structural damage to a well constructed earth dam of this size provided that static stability conditions are satisfactory and conventional safety margins exist. However, it is recommended that the prescribed seismic loading be applied in any stability analyses performed for this dam.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a. Safety. A hydraulic analysis indicated that the 6-inch pipe spillway is capable of passing lake outflow of about 1 cfs without the level of the lake exceeding the low point in the top of the dam. A hydrologic analysis of the lake watershed area, as discussed in Section 5, paragraph 5.1d, indicated that for storm runoff of probable maximum flood magnitude, the recommended spillway design flood, the lake outflow would be on the order of 596 cfs, and that for the 1 percent chance (100-year frequency) flood, the lake outflow would be about 1 cfs.

Seepage and stability analyses of the dam were not available for review, and therefore, no judgment could be made with respect to the structural stability of the dam.

Several items were noticed during the visual inspection that could adversely affect the safety of the dam. These items include seepage, trees and brush on the upstream and downstream faces of the dam, settlement of the embankment, conditions conducive to clogging of the spillway pipe, and the lack of adequate slope protection to prevent erosion of the upstream face of the dam by wave action or fluctuations in the lake surface level.

b. Adequacy of Information. Due to lack of design and construction data, the assessments reported herein were based on external conditions as determined during the visual inspection. The assessment of the hydrology of the watershed and capacity of the spillway were based on a hydrologic/hydraulic study as indicated in Section 5. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

c. Urgency. The remedial measures recommended in paragraph 7.2 for the items concerning the safety of the dam noted in paragraph 7.1a should be accomplished without undue delay. The item recommended in paragraph 7.2a

concerning the provision of additional spillway capacity should be pursued on a high priority basis.

d. Necessity for Phase II. Based on the results of the Phase I inspection, a Phase II investigation is not recommended.

e. Seismic Stability. The dam is located in an area close to the boundary separating the Zone I and Zone II seismic probability areas. An earthquake of the magnitude that might occur in this area would not be expected to cause structural damage to a well constructed earth dam of this size provided that static stability conditions are satisfactory and conventional safety margins exist. However, it is recommended that the prescribed seismic loading be applied in any stability analyses performed for this dam.

7.2 REMEDIAL MEASURES

a. Recommendations. The following actions are recommended:

(1) Based upon criteria set forth in the recommended guidelines, spillway size and/or height of dam should be increased in order to pass lake outflow resulting from a storm of probable maximum flood magnitude, which is the recommended spillway design flood for this dam. In either case, the spillway should be protected to prevent erosion.

(2) Obtain the necessary soil data and perform dam seepage and stability analyses in order to determine the structural stability of the dam for all operational conditions. Seepage and stability analyses should be performed by a qualified professional engineer experienced in the design and construction of earthen dams.

(3) Restore the dam crest to a uniform elevation and monitor the top of the dam through the area of suspected settlement in order to determine the extent of possible future settlement and the remedial work required to compensate for such settlement. The crest of the dam should be uniform throughout without low areas that reduce dam freeboard and penalize spillway capacity.

b. Operations and Maintenance (O & M) Procedures. The following O & M Procedures are recommended:

(1) Provide some means of controlling seepage evident in the area adjacent to the downstream toe of the dam. Uncontrolled seepage can lead to a piping condition (progressive internal erosion) which could result in failure of the dam. Drainage of the area affected by seepage should be one of the objectives of the seepage control measures since saturation of the soil adjacent to the dam weakens the foundation which could impair the stability of the embankment.

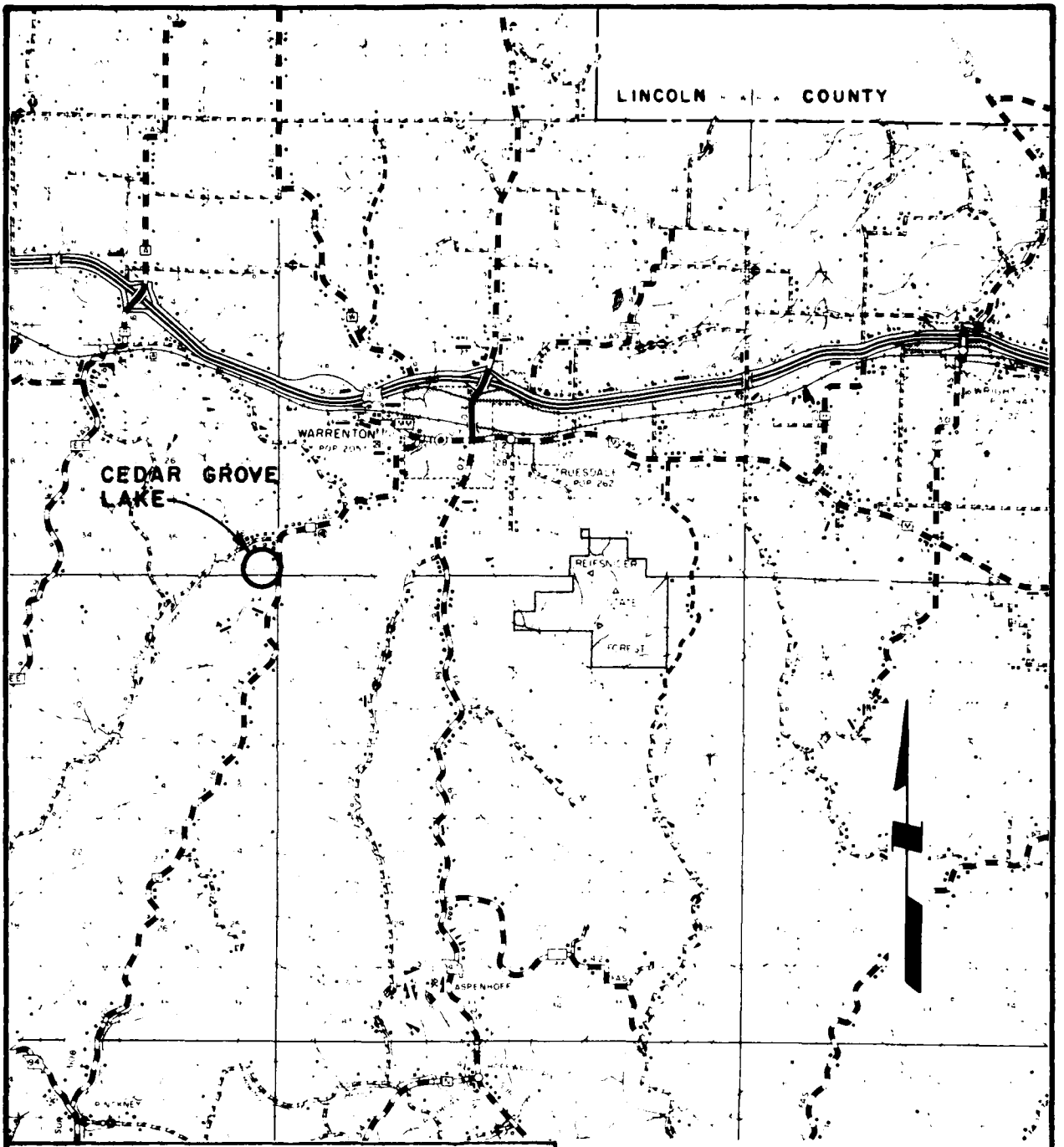
(2) Remove the trees and brush from the dam proper and the areas adjacent to the downstream toe of slope. The removal of trees should be performed under the direction and guidance of an engineer experienced in the design and construction of earthen dams, since indiscriminate clearing can jeopardize the safety of the dam. Once the dam and adjacent downstream area are cleared of trees and brush, they should be thoroughly examined by an engineer for seepage, erosion, sloughing and other signs of instability. The existing turf cover should be restored if destroyed or missing. Maintain the turf cover at a height that will not hinder inspection of the embankment or provide cover for burrowing animals. Holes from tree roots and voids created by burrowing animals can provide passageways for seepage that could lead to a piping condition and potential failure of the dam.

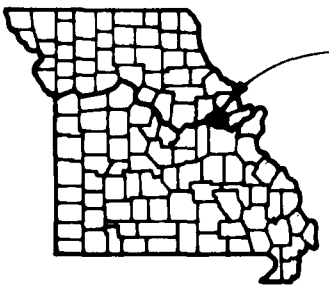
(3) Provide some form of protection other than grass at and above the normal waterline in order to prevent erosion. A grass covered slope is not considered adequate protection to prevent erosion by wave action or by a fluctuating lake level.

(4) Remove the dense growth of cattails from the area of the reservoir in the vicinity of the 6-inch pipe spillway. In addition to impeding flow to the pipe, the cattails can hinder maintenance of the pipe when blockage by floating objects and/or debris occurs. Although this outlet is considered to be unusually small, it, at present, offers the only relief for lake surcharge, and if blocked, overtopping of the dam could occur.

(5) Provide maintenance of all areas of the dam and spillways on a regularly scheduled basis in order to insure features of being in satisfactory operating condition.

(6) A detailed inspection of the dam should be instituted on a regular basis by an engineer experienced in the design and construction of dams. It is also recommended that records be kept for future reference of all inspections made and remedial measures taken.





LOCATION MAP

CEDAR GROVE LAKE

0 1 2 3 4

SCALE (MILES)

REGIONAL VICINITY MAP

PLATE 1

APPROXIMATE EXTENT OF DOWNSTREAM DAMAGE ZONE.

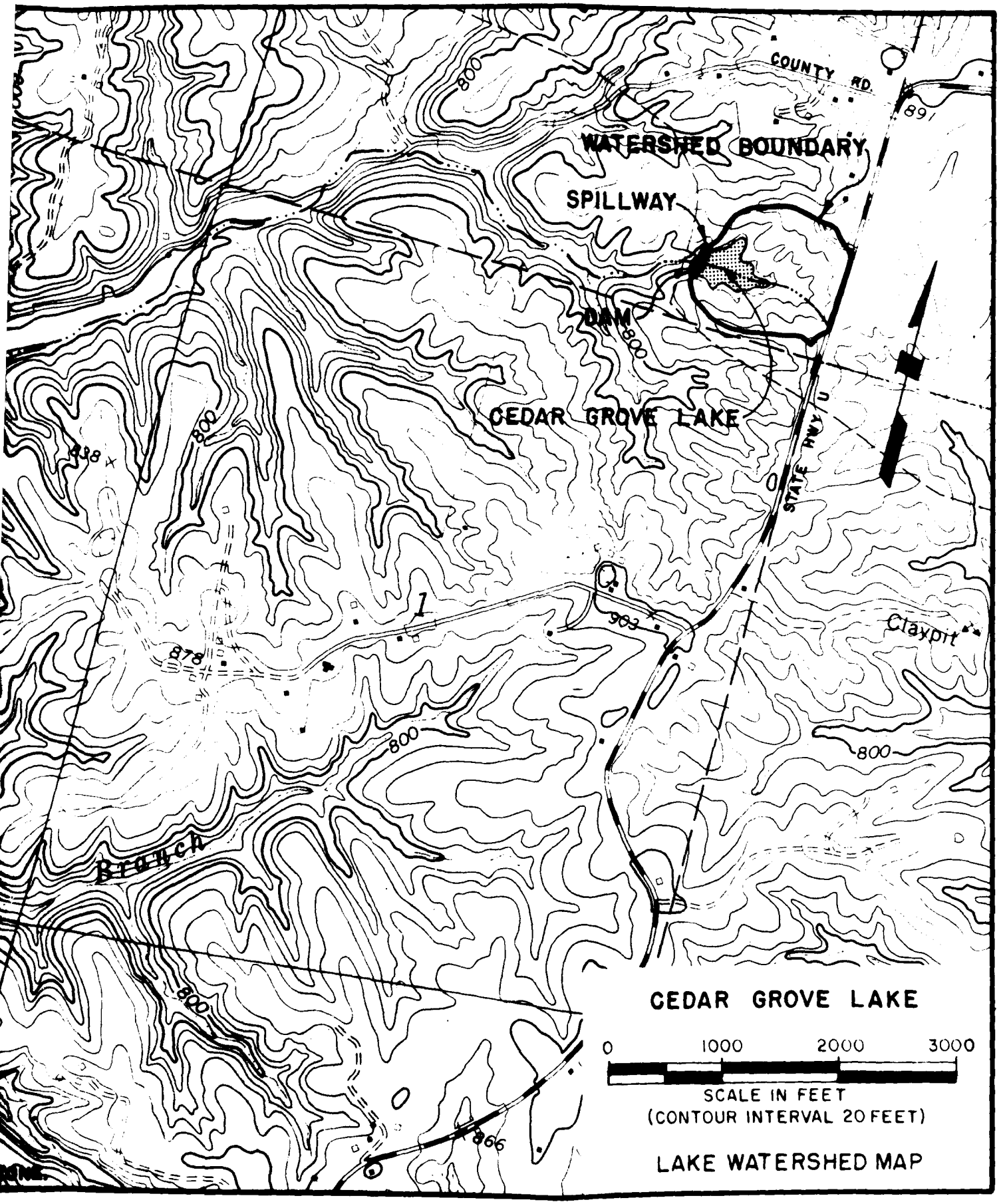
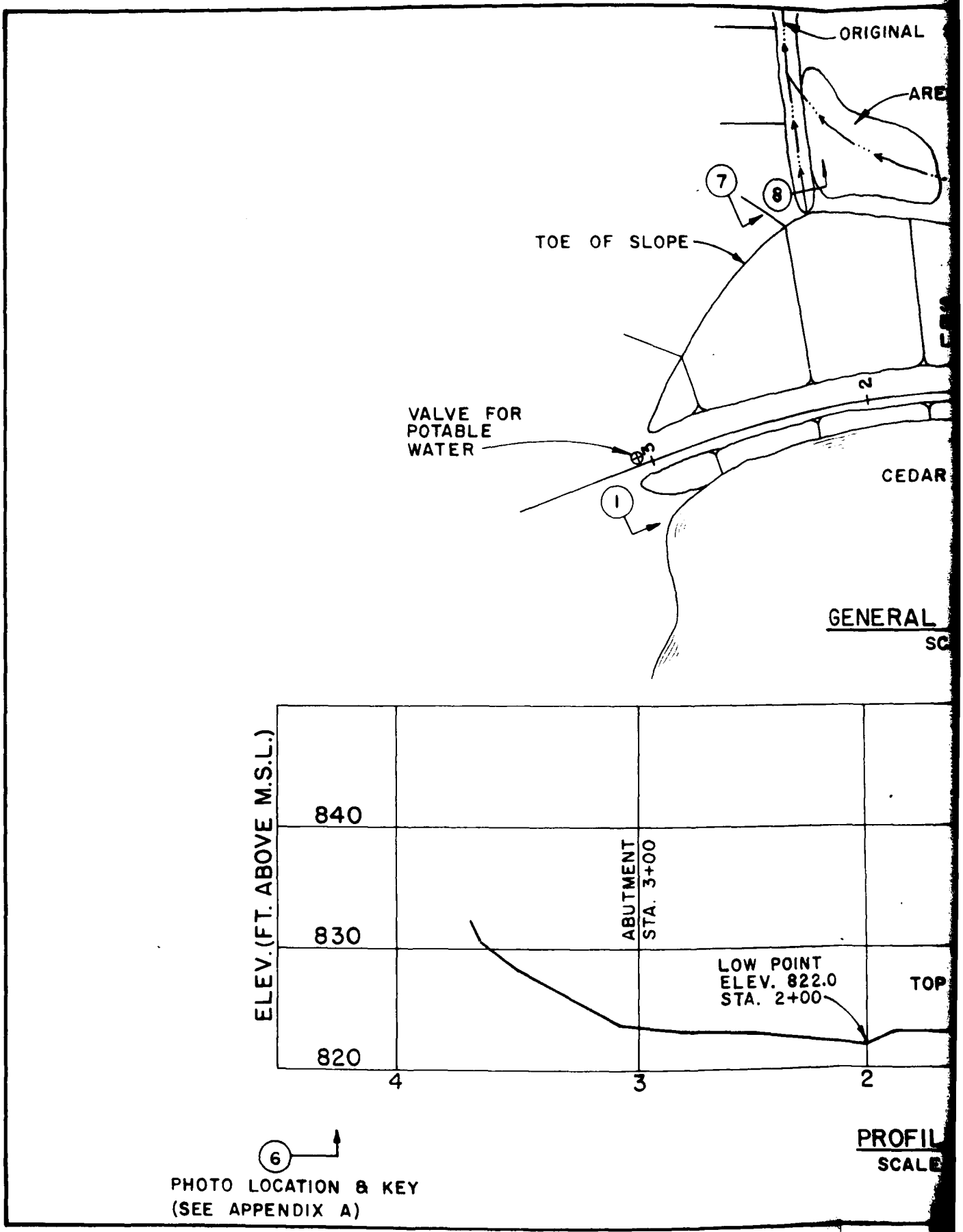
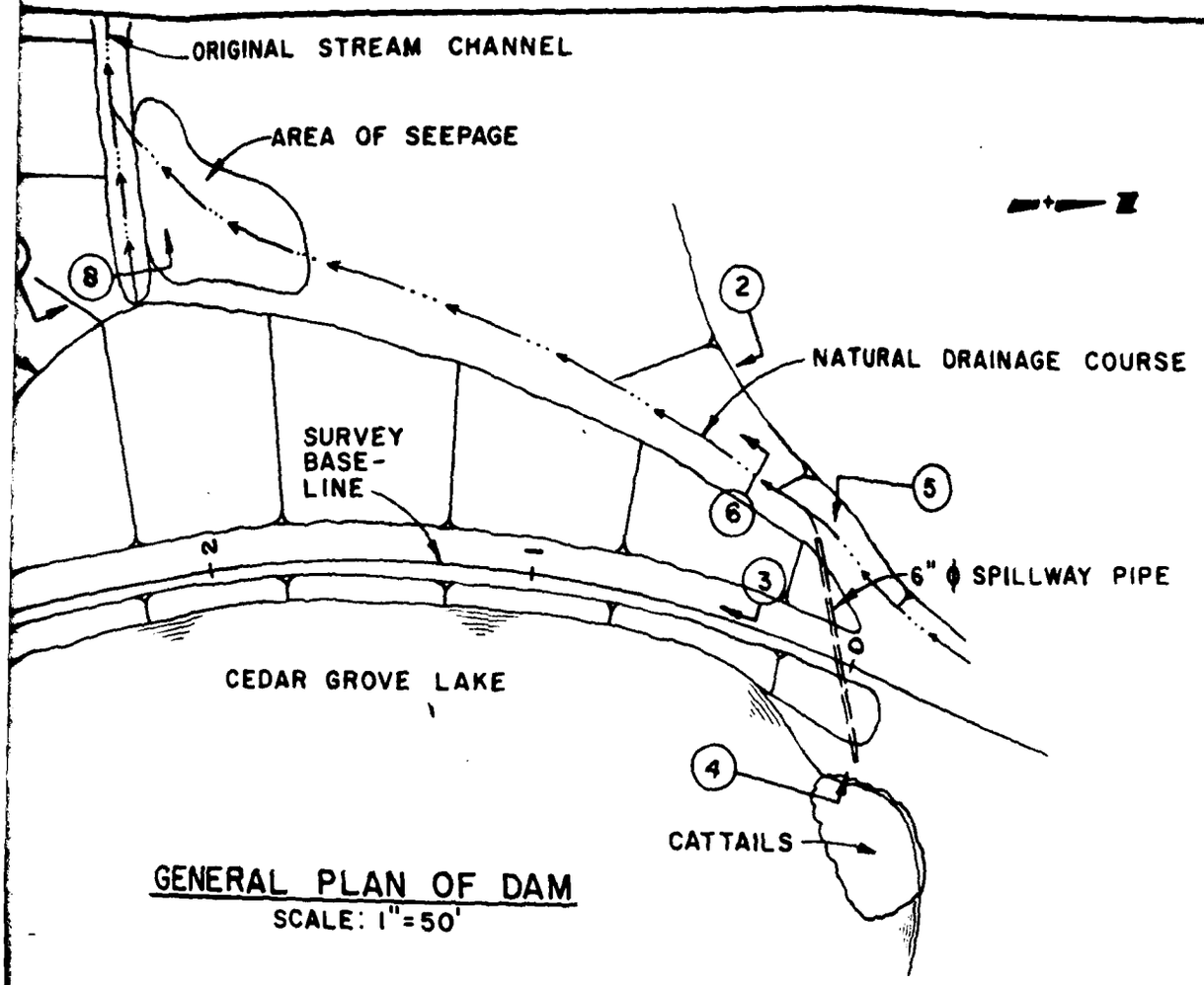
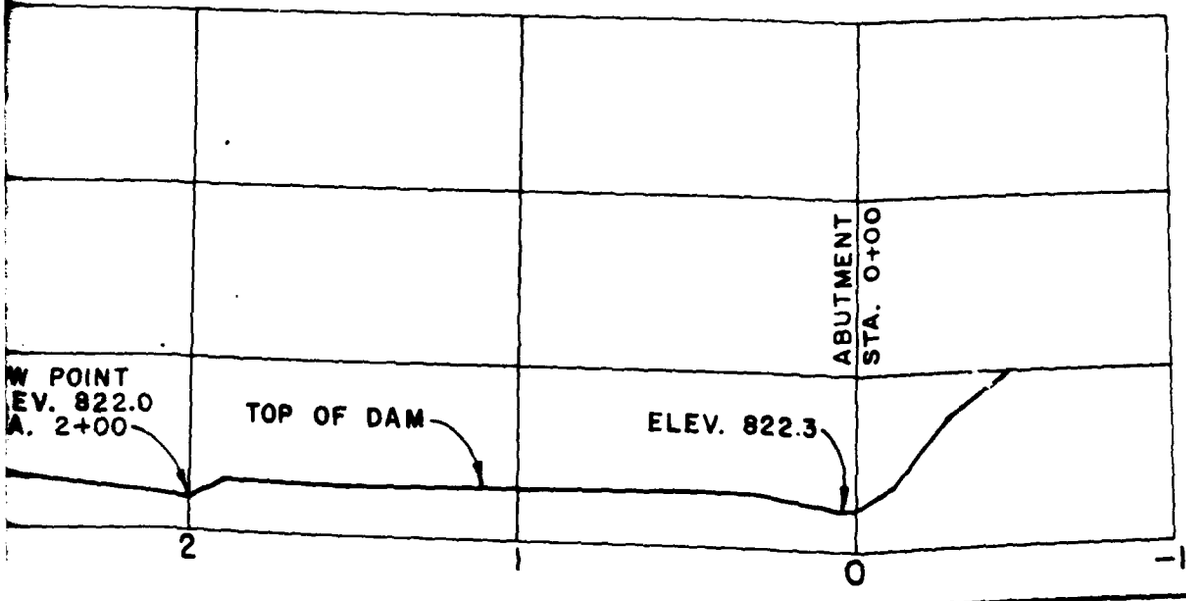

COUNTY RD.
891
WATERSHED BOUNDARY
SPILLWAY
DAM
800
CEDAR GROVE LAKE
STATE HWY U
838
878
903
Claypit
Branch
866
CEDAR GROVE LAKE
0
1000
2000
3000
SCALE IN FEET
(CONTOUR INTERVAL 20 FEET)
LAKE WATERSHED MAP

PLATE 2


ORIGINAL
ARE
7
8
TOE OF SLOPE
2
VALVE FOR
POTABLE
WATER
3
1
CEDAR
GENERAL
SC
ELEV.(FT. ABOVE M.S.L.)
840
830
820
ABUTMENT
STA. 3+00
LOW POINT
ELEV. 822.0
STA. 2+00
TOP
4
3
2
PROFIL
SCALE
6
PHOTO LOCATION & KEY
(SEE APPENDIX A)



GENERAL PLAN OF DAM
SCALE: 1"=50'

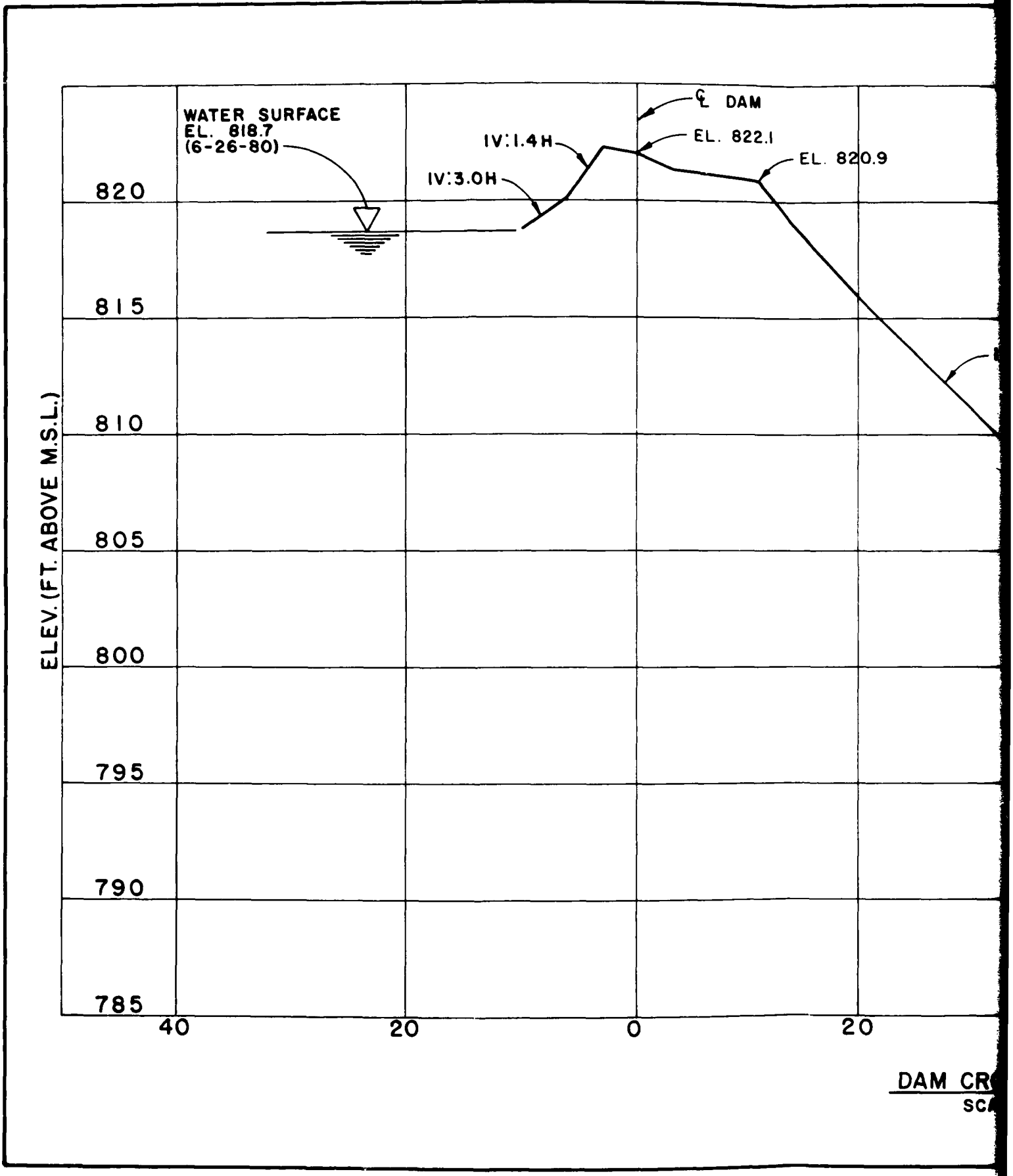


PROFILE DAM CREST
SCALES: 1"=10'V., 1"=50'H.

CEDAR GROVE LAKE
DAM PLAN & PROFILE

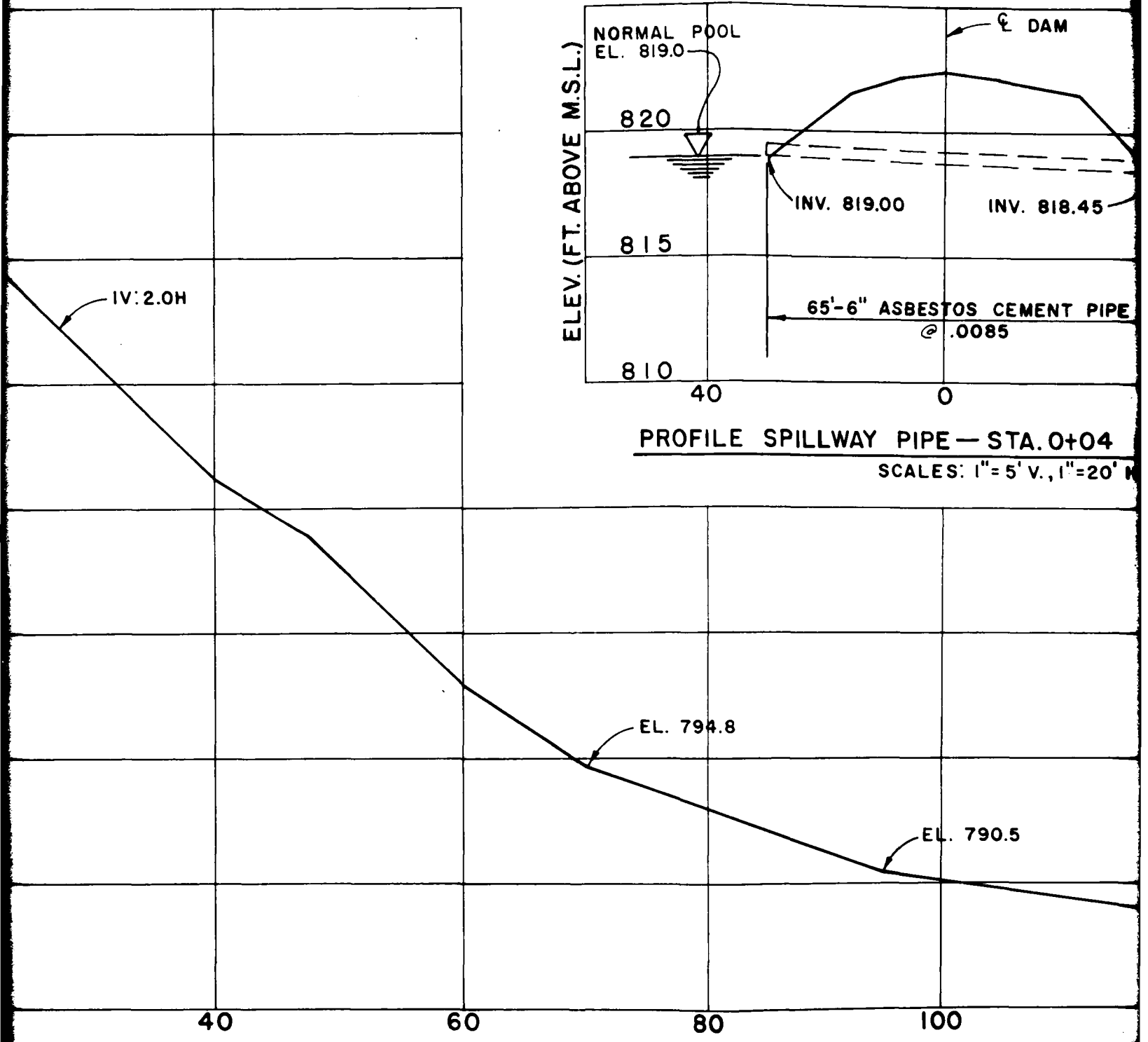
Horner & Shifrin, Inc. August 1980

PLATE 3


WATER SURFACE
EL. 818.7
(6-26-80)
℄ DAM
EL. 822.1
EL. 820.9
1V:1.4H
1V:3.0H
820
815
810
805
800
795
790
785
ELEV. (FT. ABOVE M.S.L.)
40
20
0
20
DAM CR
SC

PROFILE SPILLWAY PIPE — STA. 0+04

SCALES: 1" = 5' V., 1" = 20' H



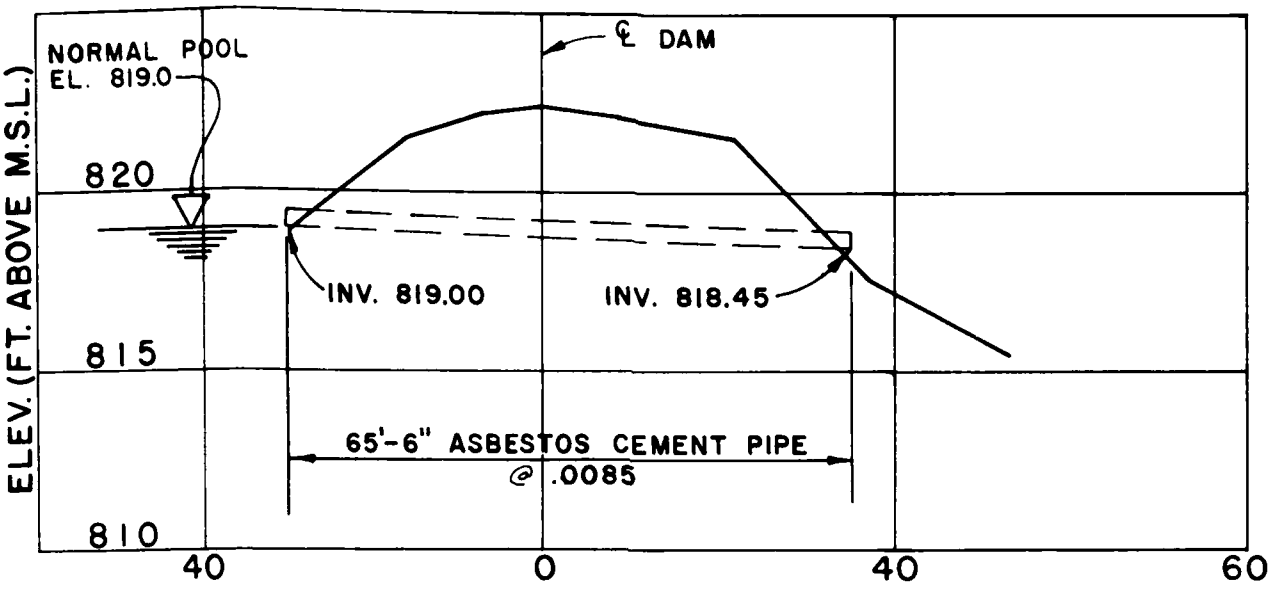
DAM CROSS-SECTION STA. 2+15

SCALES: 1" = 5' V., 1" = 20' H.

D

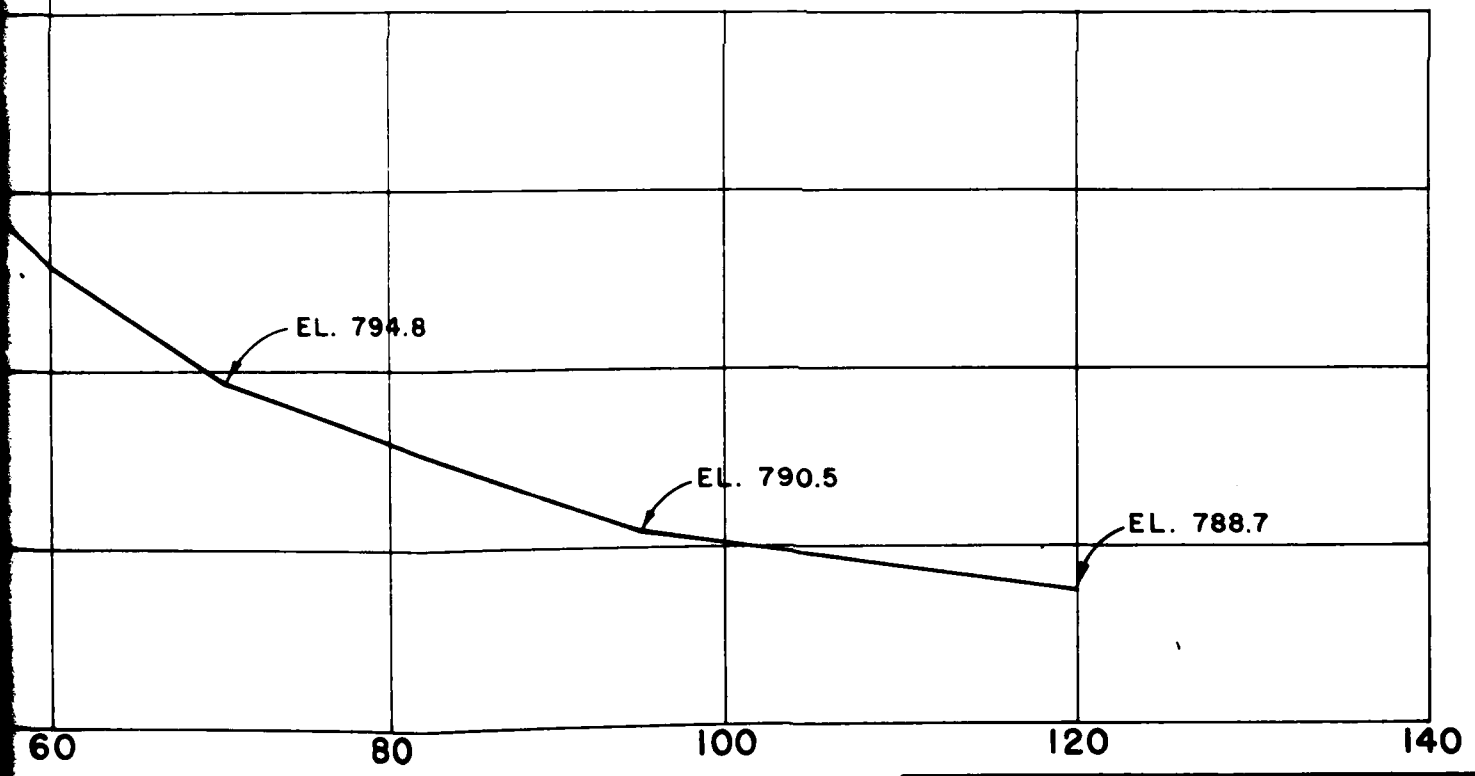
Horn

2



PROFILE SPILLWAY PIPE — STA. 0+04 (SKEW 57° 30' R.A.)

SCALES: 1" = 5' V., 1" = 20' H.



CEDAR GROVE LAKE
DAM CROSS-SECTION &
SPILLWAY PROFILE

Horner & Shifrin, Inc. August 1980

PLATE 4

APPENDIX A

INSPECTION PHOTOGRAPHS

NO. 1: UPSTREAM FACE OF DAM

NO. 2: DOWNSTREAM FACE OF DAM

NO. 3: CREST OF DAM

NO. 4: UPSTREAM END OF SPILLWAY PIPE

NO. 5: DOWNSTREAM END OF SPILLWAY PIPE

NO. 6: SPILLWAY OUTLET CHANNEL AND DRAINAGE COURSE

NO. 7: MARSHY AREA ADJACENT TO TOE OF DAM

NO. 8: SEEPAGE IN DOWNSTREAM CHANNEL AT TOE OF DAM

APPENDIX B

HYDROLOGIC AND HYDRAULIC ANALYSES

HYDROLOGIC AND HYDRAULIC COMPUTATIONS

1. The HEC-1 Dam Safety Version (July 1978, Modified 26 February 1979) program was used to develop inflow and outflow hydrographs and dam overtopping analyses, with hydrologic inputs as follows:

a. Probable maximum precipitation (200 sq. mile, 24-hour value equals 25.2 inches) from Hydrometeorological Report No. 33. The precipitation data used in the analysis of the 1 percent (100-year frequency) flood was provided by the St. Louis District, Corps of Engineers.

b. Drainage area = 0.043 square miles = 28 acres.

c. SCS parameters:

Time of Concentration (T_c) = $\left(\frac{11.9L^3}{H}\right)^{0.385}$ = 0.10 hours

Where: T_c = Travel time of water from hydraulically most distant point to point of interest, hours.

L = Length of longest watercourse = 0.24 miles.

H = Elevation difference = 61 feet.

The time of concentration (T_c) was obtained using Method C as described in Figure 30, "Design of Small Dams", by the United States Department of the Interior, Bureau of Reclamation, and was verified using average channel velocity estimates and watercourse lengths.

Lag time = 0.06 hours (0.60 Tc)
Hydrologic soil group = C (100% Lindley and Hatton Series per SCS County Soil Report)

Soil type CN = 75 (AMC II, 100-yr flood condition)
= 88 (AMC III, PMF condition)

2. Flow through the 6-inch diameter outlet pipe was determined using Bernoulli's equation for pressure flow in pipes. A pipe friction factor (n) of 0.010 was used. Losses, including entrance, pipe and exit losses totaled 4.1 velocity heads. Reference "Handbook of Hydraulics", Fifth Edition, by King & Brater, pages 8-5 and 8-6.

Discharge quantities, determined as described herein, were plotted versus corresponding lake water surface elevations to determine the discharge rating curve for the pipe spillway. These values were entered the program on the Y4 and Y5 cards.

3. The profile of the dam crest is irregular and flow over the dam cannot be determined by application of conventional weir formulas. Crest length and elevation data for the dam crest proper were entered into the HEC-1 Program on the $L and the $V cards. The program assumes that flow over the dam crest section occurs at critical depth and computes internally the flow over the dam crest and adds this flow to the flow thru the spillway as entered on the Y4 and Y5 cards.

```
A1       ANALYSIS OF DAM OVERTOPPING USING RATIOS OF PMF
A2       HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF CEDAR GROVE DAM
A3       RATIOS OF PMF ROUTED THROUGH RESERVOIR
B     288       0       5       0       0       0       0       0       0       0
B1      5
J       1       4       1
J1    .20     .21     .50      1.
K       0  INFLOW                                       1
K1       INFLOW HYDROGRAPH
M       1       2   0.043                       1.0                       1
P       0    25.2     102     120     130
T                                                      -1     -88
W2          0.060
X    -1.0    -.10     2.0
K       1     DAM                                       1
K1       RESERVOIR ROUTING BY MODIFIED PULS
Y                                1       1
Y1      1                                           20.01      -1
Y4    819  820.25  821.25  822.25  825.25  829.25
Y5      0      .9     1.1     1.3     1.8     2.3
$A      0     2.9     4.8    12.2
$E798.30     819     820     840
$$    819
$D    822
$L      0      19      35      73     310     330     372     411
$V    822   822.3   822.4   822.8   823.3   823.8   827.4   829.9
K      99
```

```
A1       ANALYSIS OF DAM OVERTOPPING USING 100-YR FLOOD
A2       HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF CEDAR GROVE DAM
A3       100-YR FLOOD ROUTED THROUGH RESERVOIR
B     288        0        5                                                  4
B1      5
J       1        1        1
J1     1.
K       0  INFLOW                                          1
K1       INFLOW HYDROGRAPH
M       0        2    0.043                        1.0                      1
O     288    7.094
O1   .006     .006     .006     .006     .006     .006     .006     .006     .006     .006
O1   .006     .006     .006     .006     .006     .006     .006     .006     .006     .006
O1   .006     .006     .006     .006     .006     .006     .006     .006     .006     .006
O1   .006     .006     .006     .006     .006     .006     .006     .006     .006     .006
O1   .006     .006     .006     .006     .006     .006     .006     .006     .006     .006
O1   .006     .006     .006     .006     .006     .006     .006     .006     .006     .006
O1   .006     .006     .006     .006     .006     .006     .006     .006     .006     .006
O1   .006     .006     .014     .014     .014     .014     .014     .014     .014     .014
O1   .014     .014     .014     .014     .014     .014     .014     .014     .014     .014
O1   .014     .014     .014     .014     .014     .014     .014     .014     .014     .014
O1   .014     .014     .014     .014     .014     .014     .014     .014     .024     .024
O1   .024     .024     .024     .024     .024     .024     .024     .024     .024     .024
O1   .024     .024     .024     .024     .024     .024     .029     .029     .029     .029
O1   .029     .029     .060     .060     .060     .060     .060     .060     .129     .129
O1   .130     .247     .247     .546     .826     .380     .247     .130     .130     .129
O1   .060     .060     .060     .060     .060     .060     .029     .029     .029     .029
O1   .029     .029     .024     .024     .024     .024     .024     .024     .024     .024
O1   .024     .024     .024     .024     .024     .024     .024     .024     .024     .024
O1   .014     .014     .014     .014     .014     .014     .014     .014     .014     .014
```

100-YR. FLOOD (Cont'd)

```
O1   .014    .014    .014    .014    .014    .014    .014    .014    .014    .014
O1   .014    .014    .014    .014    .014    .014    .014    .014    .014    .014
O1   .014    .014    .014    .014    .014    .014    .006    .006    .006    .006
O1   .006    .006    .006    .006    .006    .006    .006    .006    .006    .006
O1   .006    .006    .006    .006    .006    .006    .006    .006    .006    .006
O1   .006    .006    .006    .006    .006    .006    .006    .006    .006    .006
O1   .006    .006    .006    .006    .006    .006    .006    .006    .006    .006
O1   .006    .006    .006    .006    .006    .006    .006    .006    .006    .006
O1   .006    .006    .006    .006    .006    .006    .006    .006    .006    .006
O1   .006    .006    .006    .006    .006    .006    .006    .006
T                                                     -1     -75
W2          0.060
X    -1.0    -.10     2.0
K      1     DAM                                       1
K1       RESERVOIR ROUTING BY MODIFIED PULS


Y                                 1       1
Y1     1                                             20.01      -1
Y4   819  820.25  821.25  822.25  825.25  829.25
Y5     0      .9     1.1     1.3     1.8     2.3
$A     0     2.9     4.8    12.2
$E798.30     819     820     840
$$   819
$D   822
$L     0      19      35      73     310     330     372     411
$V   822   822.3   822.4   822.8   823.3   823.8   827.4   829.9
K     99
```

ANALYSIS OF DAM OVERTOPPING USING RATIOS OF PMF
HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF CEDAR GROVE DAM
RATIOS OF PMF ROUTED THROUGH RESERVOIR

JOB SPECIFICATION

NQ	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
288	0	5	0	0	0	0	0	0	0
			JOPER	NWT	LROPT	TRACE			
			5	0	0	0			

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NRTIO= 4 LRTIO= 1
RTIOS= .20 .21 .50 1.00

********** ********** ********** ********** **********

SUB-AREA RUNOFF COMPUTATION

INFLOW HYDROGRAPH

	ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
	INFLOW	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	2	.04	0.00	.04	1.00	0.000	0	1	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	25.20	102.00	120.00	130.00	0.00	0.00	0.00

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	-1.00	-88.00	0.00	0.00

CURVE NO = -88.00 WETNESS = -1.00 EFFECT CN = 88.00

UNIT HYDROGRAPH DATA
TC= 0.00 LAG= .06

RECESSION DATA
STRTQ= -1.00 QRCSN= -.10 RTIOR= 2.00

TIME INCREMENT TOO LARGE--(NMIN IS GT LAG/2)

UNIT HYDROGRAPH 6 END OF PERIOD ORDINATES, TC= 0.00 HOURS, LAG= .06 VOL= 1.00
191. 105. 27. 7. 2. 0.

0 MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	END-OF-PERIOD FLOW COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.05	1	.01	0.00	.01	0.	1.01	12.05	145	.21	.21	.01	48.
1.01	.10	2	.01	0.00	.01	0.	1.01	12.10	146	.21	.21	.01	63.
1.01	.15	3	.01	0.00	.01	0.	1.01	12.15	147	.21	.21	.01	67.
1.01	.20	4	.01	0.00	.01	0.	1.01	12.20	148	.21	.21	.01	68.
1.01	.25	5	.01	0.00	.01	0.	1.01	12.25	149	.21	.21	.01	69.
1.01	.30	6	.01	0.00	.01	0.	1.01	12.30	150	.21	.21	.01	69.
1.01	.35	7	.01	0.00	.01	0.	1.01	12.35	151	.21	.21	.01	69.
1.01	.40	8	.01	0.00	.01	0.	1.01	12.40	152	.21	.21	.01	69.
1.01	.45	9	.01	0.00	.01	0.	1.01	12.45	153	.21	.21	.01	69.
1.01	.50	10	.01	0.00	.01	0.	1.01	12.50	154	.21	.21	.01	69.
1.01	.55	11	.01	0.00	.01	0.	1.01	12.55	155	.21	.21	.01	70.
1.01	1.00	12	.01	0.00	.01	0.	1.01	13.00	156	.21	.21	.00	70.
1.01	1.05	13	.01	0.00	.01	0.	1.01	13.05	157	.26	.25	.01	78.
1.01	1.10	14	.01	0.00	.01	0.	1.01	13.10	158	.26	.25	.01	82.
1.01	1.15	15	.01	0.00	.01	0.	1.01	13.15	159	.26	.25	.00	83.
1.01	1.20	16	.01	0.00	.01	0.	1.01	13.20	160	.26	.25	.00	84.
1.01	1.25	17	.01	0.00	.01	0.	1.01	13.25	161	.26	.25	.00	84.
1.01	1.30	18	.01	0.00	.01	0.	1.01	13.30	162	.26	.25	.00	84.
1.01	1.35	19	.01	0.00	.01	0.	1.01	13.35	163	.26	.25	.00	84.
1.01	1.40	20	.01	.00	.01	0.	1.01	13.40	164	.26	.25	.00	84.
1.01	1.45	21	.01	.00	.01	0.	1.01	13.45	165	.26	.25	.00	84.
1.01	1.50	22	.01	.00	.01	0.	1.01	13.50	166	.26	.25	.00	84.
1.01	1.55	23	.01	.00	.01	0.	1.01	13.55	167	.26	.25	.00	84.
1.01	2.00	24	.01	.00	.01	0.	1.01	14.00	168	.26	.25	.00	84.
1.01	2.05	25	.01	.00	.01	0.	1.01	14.05	169	.32	.32	.00	97.
1.01	2.10	26	.01	.00	.01	0.	1.01	14.10	170	.32	.32	.00	103.
1.01	2.15	27	.01	.00	.01	1.	1.01	14.15	171	.32	.32	.00	105.
1.01	2.20	28	.01	.00	.01	1.	1.01	14.20	172	.32	.32	.00	106.
1.01	2.25	29	.01	.00	.01	1.	1.01	14.25	173	.32	.32	.00	106.
1.01	2.30	30	.01	.00	.01	1.	1.01	14.30	174	.32	.32	.00	106.
1.01	2.35	31	.01	.00	.01	1.	1.01	14.35	175	.32	.32	.00	106.
1.01	2.40	32	.01	.00	.01	1.	1.01	14.40	176	.32	.32	.00	106.
1.01	2.45	33	.01	.00	.01	1.	1.01	14.45	177	.32	.32	.00	106.
1.01	2.50	34	.01	.00	.01	1.	1.01	14.50	178	.32	.32	.00	106.
1.01	2.55	35	.01	.00	.01	1.	1.01	14.55	179	.32	.32	.00	106.
1.01	3.00	36	.01	.00	.01	1.	1.01	15.00	180	.32	.32	.00	106.
1.01	3.05	37	.01	.00	.01	1.	1.01	15.05	181	.20	.19	.00	82.
1.01	3.10	38	.01	.00	.01	1.	1.01	15.10	182	.39	.39	.00	106.
1.01	3.15	39	.01	.00	.01	1.	1.01	15.15	183	.39	.39	.00	123.
1.01	3.20	40	.01	.00	.01	1.	1.01	15.20	184	.59	.58	.00	165.
1.01	3.25	41	.01	.00	.01	1.	1.01	15.25	185	.68	.68	.00	205.
1.01	3.30	42	.01	.00	.01	2.	1.01	15.30	186	1.66	1.65	.01	406.
1.01	3.35	43	.01	.00	.01	2.	1.01	15.35	187	2.73	2.72	.01	717.
1.01	3.40	44	.01	.00	.01	2.	1.01	15.40	188	1.07	1.07	.00	543.
1.01	3.45	45	.01	.01	.01	2.	1.01	15.45	189	.68	.68	.00	331.
1.01	3.50	46	.01	.01	.01	2.	1.01	15.50	190	.59	.58	.00	236.
1.01	3.55	47	.01	.01	.01	2.	1.01	15.55	191	.39	.39	.00	168.
1.01	4.00	48	.01	.01	.01	2.	1.01	16.00	192	.39	.39	.00	139.
1.01	4.05	49	.01	.01	.01	2.	1.01	16.05	193	.30	.30	.00	115.

1.01	4.10	50	.01	.01	.01	2.	1.01	16.10	194	.30	.30	.00	103.
1.01	4.15	51	.01	.01	.01	2.	1.01	16.15	195	.30	.30	.00	100.
1.01	4.20	52	.01	.01	.01	2.	1.01	16.20	196	.30	.30	.00	100.
1.01	4.25	53	.01	.01	.01	2.	1.01	16.25	197	.30	.30	.00	100.
1.01	4.30	54	.01	.01	.01	2.	1.01	16.30	198	.30	.30	.00	100.
1.01	4.35	55	.01	.01	.01	2.	1.01	16.35	199	.30	.30	.00	100.
1.01	4.40	56	.01	.01	.01	2.	1.01	16.40	200	.30	.30	.00	100.
1.01	4.45	57	.01	.01	.01	2.	1.01	16.45	201	.30	.30	.00	100.
1.01	4.50	58	.01	.01	.01	2.	1.01	16.50	202	.30	.30	.00	100.
1.01	4.55	59	.01	.01	.01	2.	1.01	16.55	203	.30	.30	.00	100.
1.01	5.00	60	.01	.01	.01	2.	1.01	17.00	204	.30	.30	.00	100.
1.01	5.05	61	.01	.01	.01	2.	1.01	17.05	205	.24	.24	.00	87.
1.01	5.10	62	.01	.01	.01	2.	1.01	17.10	206	.24	.24	.00	81.
1.01	5.15	63	.01	.01	.01	2.	1.01	17.15	207	.24	.24	.00	79.
1.01	5.20	64	.01	.01	.01	2.	1.01	17.20	208	.24	.24	.00	78.
1.01	5.25	65	.01	.01	.01	2.	1.01	17.25	209	.24	.24	.00	78.
1.01	5.30	66	.01	.01	.01	2.	1.01	17.30	210	.24	.24	.00	78.
1.01	5.35	67	.01	.01	.01	3.	1.01	17.35	211	.24	.24	.00	78.
1.01	5.40	68	.01	.01	.01	3.	1.01	17.40	212	.24	.24	.00	78.
1.01	5.45	69	.01	.01	.01	3.	1.01	17.45	213	.24	.24	.00	78.
1.01	5.50	70	.01	.01	.01	3.	1.01	17.50	214	.24	.24	.00	78.
1.01	5.55	71	.01	.01	.01	3.	1.01	17.55	215	.24	.24	.00	78.
1.01	6.00	72	.01	.01	.01	3.	1.01	18.00	216	.24	.24	.00	78.
1.01	6.05	73	.06	.04	.03	8.	1.01	18.05	217	.02	.02	.00	68.
1.01	6.10	74	.06	.04	.02	12.	1.01	18.10	218	.02	.02	.00	63.
1.01	6.15	75	.06	.04	.02	13.	1.01	18.15	219	.02	.02	.00	59.
1.01	6.20	76	.06	.04	.02	13.	1.01	18.20	220	.02	.02	.00	55.
1.01	6.25	77	.06	.04	.02	14.	1.01	18.25	221	.02	.02	.00	51.
1.01	6.30	78	.06	.04	.02	14.	1.01	18.30	222	.02	.02	.00	48.
1.01	6.35	79	.06	.04	.02	15.	1.01	18.35	223	.02	.02	.00	45.
1.01	6.40	80	.06	.05	.02	15.	1.01	18.40	224	.02	.02	.00	42.
1.01	6.45	81	.06	.05	.02	15.	1.01	18.45	225	.02	.02	.00	39.
1.01	6.50	82	.06	.05	.02	15.	1.01	18.50	226	.02	.02	.00	36.
1.01	6.55	83	.06	.05	.02	16.	1.01	18.55	227	.02	.02	.00	34.
1.01	7.00	84	.06	.05	.01	16.	1.01	19.00	228	.02	.02	.00	32.
1.01	7.05	85	.06	.05	.01	16.	1.01	19.05	229	.02	.02	.00	29.
1.01	7.10	86	.06	.05	.01	16.	1.01	19.10	230	.02	.02	.00	27.
1.01	7.15	87	.06	.05	.01	17.	1.01	19.15	231	.02	.02	.00	26.
1.01	7.20	88	.06	.05	.01	17.	1.01	19.20	232	.02	.02	.00	24.
1.01	7.25	89	.06	.05	.01	17.	1.01	19.25	233	.02	.02	.00	22.
1.01	7.30	90	.06	.05	.01	17.	1.01	19.30	234	.02	.02	.00	21.
1.01	7.35	91	.06	.05	.01	17.	1.01	19.35	235	.02	.02	.00	19.
1.01	7.40	92	.06	.05	.01	17.	1.01	19.40	236	.02	.02	.00	18.
1.01	7.45	93	.06	.05	.01	17.	1.01	19.45	237	.02	.02	.00	17.
1.01	7.50	94	.06	.05	.01	18.	1.01	19.50	238	.02	.02	.00	16.
1.01	7.55	95	.06	.05	.01	18.	1.01	19.55	239	.02	.02	.00	15.
1.01	8.00	96	.06	.05	.01	18.	1.01	20.00	240	.02	.02	.00	14.
1.01	8.05	97	.06	.05	.01	18.	1.01	20.05	241	.02	.02	.00	13.
1.01	8.10	98	.06	.05	.01	18.	1.01	20.10	242	.02	.02	.00	12.
1.01	8.15	99	.06	.05	.01	18.	1.01	20.15	243	.02	.02	.00	11.
1.01	8.20	100	.06	.06	.01	18.	1.01	20.20	244	.02	.02	.00	10.
1.01	8.25	101	.06	.06	.01	18.	1.01	20.25	245	.02	.02	.00	10.
1.01	8.30	102	.06	.06	.01	18.	1.01	20.30	246	.02	.02	.00	9.

END-OF-PERIOD FLOW (Cont'd)

1.01	8.35	103	.06	.06	.01	19.	1.01	20.35	247	.02	.02	.00	8.
1.01	8.40	104	.06	.06	.01	19.	1.01	20.40	248	.02	.02	.00	8.
1.01	8.45	105	.06	.06	.01	19.	1.01	20.45	249	.02	.02	.00	7.
1.01	8.50	106	.06	.06	.01	19.	1.01	20.50	250	.02	.02	.00	7.
1.01	8.55	107	.06	.06	.01	19.	1.01	20.55	251	.02	.02	.00	7.
1.01	9.00	108	.06	.06	.01	19.	1.01	21.00	252	.02	.02	.00	7.
1.01	9.05	109	.06	.06	.01	19.	1.01	21.05	253	.02	.02	.00	7.
1.01	9.10	110	.06	.06	.01	19.	1.01	21.10	254	.02	.02	.00	7.
1.01	9.15	111	.06	.06	.01	19.	1.01	21.15	255	.02	.02	.00	7.
1.01	9.20	112	.06	.06	.01	19.	1.01	21.20	256	.02	.02	.00	7.
1.01	9.25	113	.06	.06	.01	19.	1.01	21.25	257	.02	.02	.00	7.
1.01	9.30	114	.06	.06	.01	19.	1.01	21.30	258	.02	.02	.00	7.
1.01	9.35	115	.06	.06	.01	19.	1.01	21.35	259	.02	.02	.00	7.
1.01	9.40	116	.06	.06	.01	19.	1.01	21.40	260	.02	.02	.00	7.
1.01	9.45	117	.06	.06	.00	19.	1.01	21.45	261	.02	.02	.00	7.
1.01	9.50	118	.06	.06	.00	19.	1.01	21.50	262	.02	.02	.00	7.
1.01	9.55	119	.06	.06	.00	19.	1.01	21.55	263	.02	.02	.00	7.
1.01	10.00	120	.06	.06	.00	19.	1.01	22.00	264	.02	.02	.00	7.
1.01	10.05	121	.06	.06	.00	19.	1.01	22.05	265	.02	.02	.00	7.
1.01	10.10	122	.06	.06	.00	20.	1.01	22.10	266	.02	.02	.00	7.
1.01	10.15	123	.06	.06	.00	20.	1.01	22.15	267	.02	.02	.00	7.
1.01	10.20	124	.06	.06	.00	20.	1.01	22.20	268	.02	.02	.00	7.
1.01	10.25	125	.06	.06	.00	20.	1.01	22.25	269	.02	.02	.00	7.
1.01	10.30	126	.06	.06	.00	20.	1.01	22.30	270	.02	.02	.00	7.
1.01	10.35	127	.06	.06	.00	20.	1.01	22.35	271	.02	.02	.00	7.
1.01	10.40	128	.06	.06	.00	20.	1.01	22.40	272	.02	.02	.00	7.
1.01	10.45	129	.06	.06	.00	20.	1.01	22.45	273	.02	.02	.00	7.
1.01	10.50	130	.06	.06	.00	20.	1.01	22.50	274	.02	.02	.00	7.
1.01	10.55	131	.06	.06	.00	20.	1.01	22.55	275	.02	.02	.00	7.
1.01	11.00	132	.06	.06	.00	20.	1.01	23.00	276	.02	.02	.00	7.
1.01	11.05	133	.06	.06	.00	20.	1.01	23.05	277	.02	.02	.00	7.
1.01	11.10	134	.06	.06	.00	20.	1.01	23.10	278	.02	.02	.00	7.
1.01	11.15	135	.06	.06	.00	20.	1.01	23.15	279	.02	.02	.00	7.
1.01	11.20	136	.06	.06	.00	20.	1.01	23.20	280	.02	.02	.00	7.
1.01	11.25	137	.06	.06	.00	20.	1.01	23.25	281	.02	.02	.00	7.
1.01	11.30	138	.06	.06	.00	20.	1.01	23.30	282	.02	.02	.00	7.
1.01	11.35	139	.06	.06	.00	20.	1.01	23.35	283	.02	.02	.00	7.
1.01	11.40	140	.06	.06	.00	20.	1.01	23.40	284	.02	.02	.00	7.
1.01	11.45	141	.06	.06	.00	20.	1.01	23.45	285	.02	.02	.00	7.
1.01	11.50	142	.06	.06	.00	20.	1.01	23.50	286	.02	.02	.00	7.
1.01	11.55	143	.06	.06	.00	20.	1.01	23.55	287	.02	.02	.00	7.
1.01	12.00	144	.06	.06	.00	20.	1.02	0.00	288	.02	.02	.00	7.
									SUM	32.76	31.18	1.58	11010.
										(832.)(792.)(40.)(311.77)			

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	717.	118.	38.	33.	11007.
CMS	20.	3.	1.	1.	312.
INCHES		25.44	33.07	33.07	33.07
MM		646.20	840.02	840.02	840.02
AC-FT		58.	76.	76.	76.
THOUS CU M		72.	94.	94.	94.

SURFACE AREA=	0.	3.	5.	12.
CAPACITY=	0.	20.	24.	188.
ELEVATION=	798.	819.	820.	840.

SUMMARY OF DAM SAFETY ANALYSIS
PMF

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	819.00	819.00	822.00
STORAGE	20.	20.	34.
OUTFLOW	0.	0.	1.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.20	821.98	0.00	34.	1.	0.00	24.00	0.00
.21	822.10	.10	35.	2.	5.50	20.75	0.00
.50	823.17	1.17	41.	195.	9.17	15.75	0.00
1.00	823.60	1.60	43.	596.	11.08	15.67	0.00

SUMMARY OF DAM SAFETY ANALYSIS
100-YR. FLOOD

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	819.00	819.00	822.00
STORAGE	20.	20.	34.
OUTFLOW	0.	0.	1.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
1.00	821.04	0.00	29.	1.	0.00	24.00	0.00

DATE
ILME